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Can Soil Amendments Aid Revegetation of New Mexico Coal Mine Spoils?[1]

Earl F. Aldon, H. W. Springfield, and George Garcia[2]

Adding amendments did not improve seedling emergence in greenhouse tests with mountain rye, fourwing saltbush, and western wheatgrass. Shredded bark depressed herbage yields, especially where no fertilizer was supplied. Fertilizer consistently increased yield. Topsoil was not always a better growth medium than spoil.

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Soil amendments may be organic or inorganic, or combinations of the two. Straw, manure, sawdust, and bark are common organic amendments. Inorganic amendments include sand, perlite, vermiculite, and a wide variety of chemical fertilizers, particularly nitrogen and phosphorus.

This Note summarizes the results of small-scale greenhouse tests with representative spoils from two coal mines in northern New Mexico. Specifics of each experiment are given separately. The general objective was to determine whether individual or combinations of several amendments would improve germination and growth of native plants grown on mine spoils material. This information would be used as guidelines for field testing and further investigation.

RATON AREA

The Raton coalfield in northeastern New Mexico lies in rough, dissected plateau country, just east of the Sangre de Cristo Mountains. Coking coal has been mined underground in horizontal drifts which are readily accessible from the canyons. The York Canyon Mine coal bed has thin overburden, however, and is currently being developed for strip mining. The mine is located at an elevation of about 2,250

[1] *The research reported here is a contribution to the SEAM program. SEAM, an acronym for Surface Environment and Mining, is a Forest Service program to research, develop, and apply technology that will help maintain a quality environment and other surface values while helping meet the Nation's mineral requirements. This work was conducted in cooperation with Pittsburg and Midway Coal Co., and the Kaiser Steel Co. We appreciate the assistance of these companies.*

[2] *Principal Hydrologist, Plant Ecologist, and Forestry Research Technician, respectively, Rocky Mountain Forest and Range Experiment Station, located at Station's Research Work Unit at Albuquerque, in cooperation with University of New Mexico; Station's central headquarters is maintained at Fort Collins, in cooperation with Colorado State University.*

meters, in the ponderosa pine (*Pinus ponderosa* Laws.) zone where precipitation ranges from 400 to 580 millimeters.

Shredded pine bark from a nearby sawmill looked like a low-cost, readily available amendment that might be used in reclamation efforts. A study was first set up to test various rates of bark mixed with either spoil or topsoil material, and with or without fertilizer. The mixes included ¼, ½, or ¾ bark. Results showed that levels of ½ and ¾ bark were excessive. Therefore, a followup study was conducted using no more than ¼ bark.

Methods

The experiment was conducted in 1974, using plasticized pots 10 cm in diameter and 15 cm tall. Daily maximum greenhouse temperatures ranged from 22° to 32° C. Shredded ponderosa pine bark, which had been aged in large piles, was mixed with spoils (overburden) or topsoil from the York Canyon Mine.

A 10-5-5 fertilizer was used. Procedures for adding the fertilizer were standardized. The upper half of the mixture in each pot was removed; the proper amount of fertilizer was thoroughly mixed in; then the mixture was returned to the pot. In each pot, 20 seeds of mountain rye (*Secale montanum*) were planted 1.25 cm deep.

Seedlings were counted twice weekly for 3 weeks, after which they were thinned to six seedlings per pot. At the termination of the experiment in 60 days, the maximum height of the seedlings in each pot was measured; then the plants were clipped to soil level, and weighed both green and ovendry.

The following four planting media were used:

Spoil only.
¾ spoil, ¼ bark.
Topsoil only.
¾ topsoil, ¼ bark.

Fertilizer treatments were none, low, and high, as follows:

F_0—no fertilizer.
F_1—0.72 g/pot (800 lb/acre).
F_2—1.44 g/pot (1,600 lb/acre).

Design of the experiment was factorial, with four replications, for a total of 48 pots.

Results

Emergence of mountain rye seedlings generally was higher in spoil than in topsoil (table 1). For example, more than 70 percent of the seeds planted in unfertilized spoil produced seedlings, compared with less than 50 percent in unfertilized topsoil. The overall effects of fertilizer and bark on seedling emergence were negligible. Emergence was nearly the same in spoil and topsoil where bark was added, provided no fertilizer had been applied; but applying fertilizer to a mix of bark and topsoil (1:3 ratio) severely depressed emergence. In contrast, applying fertilizer to a mix of bark and spoil did not depress emergence.

Table 1.--Emergence, growth, and yield of mountain rye in York Canyon mine spoil and topsoil, amended with bark and no, low, and high levels of fertilizer (10-5-5), 60 days after planting, 1974, Raton coalfield area

Planting medium and fertilizer level	Emergence	Leaf length	Ovendry yield
	Percent	*cm*	*g*
Spoil only:			
F_0 (none)	72.50	25.50	0.635
F_1 (low)	41.25	54.00	2.445
F_2 (high)	71.25	39.75	4.332
3/4 spoil, 1/4 bark:			
F_0	70.00	19.75	.265
F_1	73.75	36.25	1.838
F_2	62.50	43.75	3.200
Mean	65.21	36.50	2.119
Topsoil only:			
F_0	48.25	45.25	.978
F_1	55.00	43.75	3.202
F_2	57.50	42.25	4.410
3/4 topsoil, 1/4 bark:			
F_0	71.25	23.75	.215
F_1	30.00	45.00	1.492
F_2	48.75	51.00	3.120
Mean	51.79	41.83	2.236

Leaves generally were longer on plants growing in topsoil than on plants in spoil material. There were, however, several exceptions. As examples, the longest leaves were on plants in spoil only fertilized at the lower level, whereas the next to the shortest leaves were on plants in ¾ topsoil, ¼ bark, unfertilized. Adding bark tended to result in shorter leaves, but the effects were not entirely consistent. When no fertilizer was applied, leaves were substantially shorter where bark was added (fig. 1). Application of fertilizer, especially at the higher rate, usually compensated for the depressing effect of the bark on leaf length. Fertilizer almost always promoted longer leaves; notable exceptions were those plants grown in

Figure 1.—Growth of mountain rye in 60 days:

Left to right—

Spoil, no fertilizer;

Spoil, with fertilizer;

¾ spoil, ¼ bark, no fertilizer;

¾ spoil, ¼ bark, with fertilizer.

topsoil only, where the higher level of fertilizer did not consistently produce longer leaves.

Plants grown in spoil material weighed essentially the same as plants grown in topsoil. Overall, the mean differences in yield were not significant. Adding bark to either the spoils or topsoil reduced the yield of mountain rye. This reduction in yield due to bark was proportionately less where fertilizers had been applied. For spoil, topsoil, and mixes, however, the application of fertilizers consistently increased yields. In all instances, the higher level of fertilization resulted in a higher yield of grass. For spoil only and topsoil only, the yield increases (compared with no fertilizer) were:

	F_1	F_2
	(*percent*)	
Spoil only	285	582
Topsoil only	227	351

Conclusions

- Seedlings emerged as well (or better) in spoil as in topsoil.
- Adding shredded pine bark or fertilizer did not consistently improve emergence.
- Fertilizer improved leaf length and plant weights in both spoil and topsoil in nearly all treatments.
- Bark depressed plant weights, especially where no fertilizer was used.
- High levels of fertilizer improved yield of mountain rye under all conditions, and was especially effective in spoil and topsoil where no bark was added.

GALLUP AREA

The three spoil materials used for this test were taken from the McKinley Mine of Pittsburg and Midway Coal Company, near Gallup, New Mexico, at an elevation of 2,000-2,100 meters and annual precipitation of 29-39 cm. The planting media for this experiment, all of clay loam texture, (table 2) were:

Old spoil, which resulted from mining in 1968.
Raw Spoil 1, from mining in 1971.
Raw Spoil 2, from mining in 1972.
Topsoil, from a big sagebrush area at the mine site.

Table 2.--Characteristics of planting media from McKinley Mine, near Gallup, New Mexico

Planting media	pH	Electrical conductivity x 10^3	N	P_2O_5	K_2O	Organic matter[1]
			- - *p/m* - -			*Percent*
Old spoil	7.3	0.96	6.5	8.5	101	6.51
Raw spoil 1	7.3	.79	4	15.5	108.5	4.43
Raw spoil 2	7.3	3.00	18	4.5	68.5	4.84
Topsoil	7.2	5.30	8	18	58	2.27

[1]High due to coal particles.

Methods

Two native forage species—fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.) and western wheatgrass (*Agropyron smithii* Rydb.)—were selected to test plant responses. Both species grow naturally near the McKinley Mine and have a high potential for revegetation. They provide good quality forage for domestic livestock as well as for wildlife, and are important soil stabilizers. Seeds of fourwing saltbush used in the experiment were collected in 1968 at Camp 8, south of Cuba, New Mexico. Seeds of western wheatgrass used were produced at the Soil Conservation Service, Los Lunas Plant Materials Center, and are identified as C-30.

A 10-5-5 fertilizer was tested at two levels:

Low—1.9 g/pot (800 lb/acre).
High—3.8 g/pot (1,600 lb/acre).

Metal pots 16.5 cm in diameter and 21.6 cm in height were filled to within 3.8 cm of the top, with 4,000 g of air-dry material. Large rocks were removed from the spoil material.

Fertilizer was added to the air-dry spoils and topsoil before seeds were planted in 1974. The top 5.0 cm of material was removed from the pot. Then, either 1.9 (low) or 3.8 (high) grams of fertilizer were thoroughly mixed with the material, and the mixture returned to the pot.

The top 1.3 cm of spoil or topsoil was removed from the pot before seeds were planted. Twenty seeds of fourwing saltbush or western wheatgrass were spaced evenly over the surface, then covered with the 1.3 cm of material previously removed.

Pots were watered at 3- or 4-day intervals to maintain moisture near field capacity. The quantity of water added was based on drying curves determined for samples of spoils used in another experiment (Aldon and Springfield 1973), but collected from the same areas as spoils used in this experiment.

The 144 pots were randomly placed on benches in a greenhouse. Air temperatures during the experiment were:

	Range	Mean
Daily maximum	27°-36°C	33°C
Daily minimum	13°-18°C	16°C

The experimental design was factorial, with six replications.

Results

Fourwing Saltbush

Maximum emergence of fourwing saltbush seedlings in 90 days was significantly less in Raw Spoil 1 than in the other two spoil materials and Topsoil (table 3). Raw Spoil 1 tended to swell and shrink and crack; consequently it was difficult to maintain moisture near field capacity.

Overall, fertilizer did not significantly influence seedling emergence. The high level of fertilizer, however, depressed emergence of saltbush seedlings in Raw Spoil 2.

At the end of 90 days, plants grown without fertilizer in Topsoil were no taller than those grown without fertilizer in Old or Raw Spoil 2 (fig. 2). Plants grown in pots with fertilizer were significantly taller than in nonfertilized pots. The high level of fertilizer, however, did not produce significantly taller plants than the low level in any material.

Plants grown in Topsoil tended to yield more than those in spoils, particularly if fertilized, but the differences were not always significant. Fertilized plants consistently outyielded unfertilized plants. At the low level of fertilization, plants in Topsoil were heavier than those in Old Spoil; plants in Topsoil and Raw Spoil 2 yielded essentially the same. Plants in Old Spoil and Topsoil weighed significantly more at the high level than at the low level, whereas plants in Raw Spoil 2 weighed the same under the two levels of fertilization. Fourwing saltbush responses to fertilizer agree with the results of Williams and O'Connor (1973) who worked with rangeland soils.

Table 3.--Emergence, height, and yield of fourwing saltbush and western wheatgrass in mine spoils and topsoil, with no, low, and high levels of fertilizer, 90 days after planting, 1974, Gallup coalfield area

Species and planting medium	Emergence, when fertilizer level is--				Height, when fertilizer level is--				Ovendry yield, when fertilizer level is--			
	None	Low	High	Mean	None	Low	High	Mean	None	Low	High	Mean
	- - *Percent* - -				- - - *cm* - - -				- - - - *g* - - - -			
FOURWING SALTBUSH:												
Old Spoil (1968)	41.5	34.7	38.2	38.1	29.2	41.2	48.5	39.6	2.5	5.7	9.1	5.8
Raw Spoil 1 (1971)	2.3	10.0	7.6	6.6	--	--	--	--	--	--	--	--
Raw Spoil 2 (1972)	42.3	41.5	25.2	36.3	32.6	43.4	44.3	40.1	3.1	6.3	6.2	5.2
Topsoil	29.3	37.2	27.9	31.5	25.2	49.1	49.7	41.3	2.2	8.5	11.5	7.4
Mean	28.8	30.8	24.7	28.1	29.0	44.6	47.5	40.3	2.6	6.8	8.9	6.1
WESTERN WHEATGRASS:												
Old Spoil (1968)	96.8	91.3	95.2	94.4	47.7	67.7	76.7	64.0	2.4	10.2	10.2	7.6
Raw Spoil 1 (1971)	29.4	65.5	57.9	50.9	37.7	66.0	65.0	56.2	.7	5.7	6.8	4.4
Raw Spoil 2 (1972)	83.8	89.3	80.6	84.6	53.0	70.1	71.9	65.0	3.5	8.3	10.2	7.3
Topsoil	90.6	94.7	95.3	93.5	46.9	62.1	69.2	59.4	2.4	8.7	11.6	7.6
Mean	75.2	85.2	82.2	80.8	46.3	66.5	70.7	61.2	2.2	8.2	9.7	6.7

Western Wheatgrass

Emergence of western wheatgrass seedlings was much higher than for fourwing saltbush (table 3). As with saltbush, however, emergence of wheatgrass was significantly less in Raw Spoil 1. Wheatgrass seedlings emerged exceptionally well in unfertilized Old Spoil.

The effect of fertilizer on emergence varied according to spoil material. Adding fertilizer to Topsoil or Raw Spoil 1 improved emergence. On the other hand, the high level of fertilizer depressed emergence somewhat, compared to the low level, in both Raw Spoils. (The interaction between spoils and fertilizer was significant at the 0.05 level.)

During the 90 days of this experiment, western wheatgrass grew well in all spoils except Raw Spoil 1, which produced the smallest plants. The average height and weight of the grass plants were practically the same in Raw Spoil 2, Old Spoil, and Topsoil.

Plants were consistently taller and heavier where fertilizer had been applied. For example, in the Old Spoil material, fertilized plants were at least 40 percent taller and four times heavier than unfertilized plants.

Doubling the amount of fertilizer generally affected yield much more than height. Plants grown in Old Spoil weighed the same, however, whether fertilized at the high or low level.

Conclusions

- Fertilizer does not improve emergence of fourwing saltbush or western wheatgrass measured after 90 days.
- Fertilizer does significantly improve height and yield of plants.
- The high level of fertilizer did not improve height of these plants, and produced only small additional gains in the yield of western wheatgrass.
- Topsoil was not significantly better as a growth medium than either a 5-year-old spoil material or a recently mined spoil material.
- One sample of recently mined spoil material did reduce emergence and growth of both species. This reduction was related to watering difficulties due to physical properties of the spoil.

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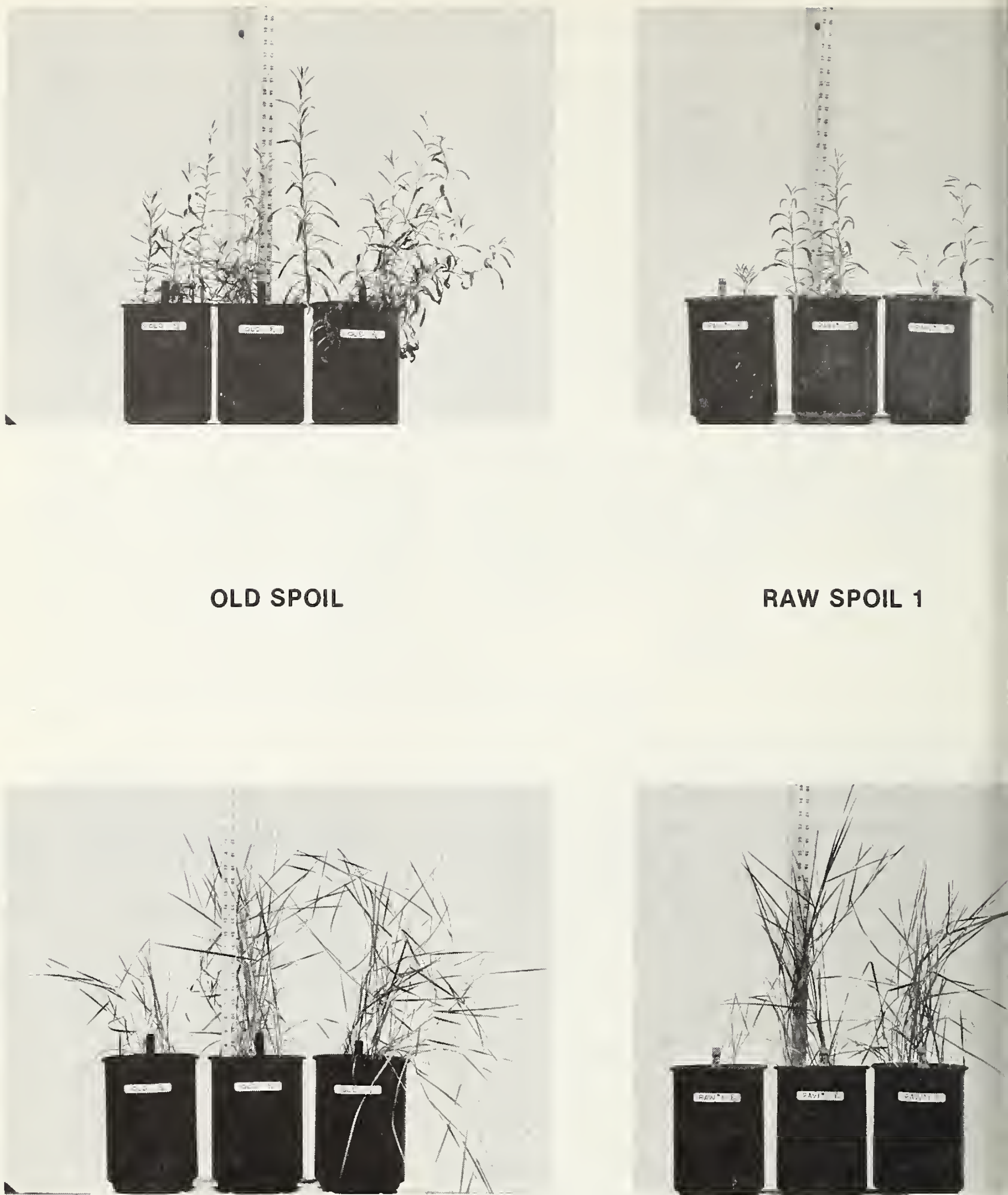

Figure 2.—Growth of fourwing saltbush and western wheatgrass in 90 days: Left to right—no fertilizer; low-level fertilizer; high-level fertilizer.

RAW SPOIL 2

TOPSOIL